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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter
Circular
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SPECIFICATIONS FOR PORTABLE FREQUENCY METER FOR FREQUENCIES FROM 1500 to 15000 KILOCYCLES, BUREAU OF STANDARDS TYPE K.

This instrument is a type which was designed by the Bureau of Standards for use by the radio inspectors of this Department. The specifications are in a form suitable for use by a manufacturer. It is estimated that the instrument can be manufactured for approximately $160 to $200. The Bureau of Standards does not manufacture or sell this or any other device.

The Bureau of Standards has made no investigation of the possible existence of patents covering any of the features of these specifications, and takes no responsibility for their freedom from patent infringement.

Frequency meters should not be sent to the Bureau of Standards for calibration. The user may calibrate the instrument himself, either from the Bureau's standard frequency signals, "standard frequency stations," or "constant frequency stations," or he may have the calibration made by a commercial standardizing laboratory. The Bureau will furnish upon application a schedule of its standard frequency signal transmissions and a pamphlet (Letter Circular 171) which includes directions for the use of harmonics to establish numerous values of frequency from a single known frequency. Information on the standard frequency stations and constant frequency stations is given each month in the Radio Service Bulletin, a monthly publication of the Department of Commerce, obtainable by purchase from the Superintendent of Documents, Government Printing Office, Washington, D.C., at 25 cents per year.

General Design.- The frequency meter (or wavemeter) is a simple series combination of capacity and inductance, with a thermogalvanometer connected to this circuit by fixed inductive coupling. The frequency range of 1500 to 15,000 kilocycles per second (200 to 20 meters) is obtained by a variable air condenser and four interchangeable coils. The condenser has such a ratio of maximum to minimum capacity and shape of plates as to give a uniform frequency spacing over the whole scale.

The various parts of the frequency meter, scheme of connections, etc., are shown on the drawings, which are considered as parts of these specifications (see paragraph on "Drawings" at end hereof). The weight of the completed frequency meter shall be as small as possible consistent with sufficient strength. Workmanship and materials throughout shall be of the best grade.

Precision.- The frequency meter is capable of measuring frequencies throughout the stated range 1500 to 15,000 kilocycles (200 to 20 meters) with a precision better than two-tenths of one per cent. The sharpness of resonance, as measured at half resonance deflection, is not less than 75 at any frequency within the stated range. (Definition and discussion of sharpness of resonance are given in Bureau of Standards Circular No.74, pp.36 and 313, and Technologic Paper No.256, pp.216 and 228.) When made as prescribed in these specifications the frequency meter will meet these requirements.

Condenser.- The variable air condenser shall be of the panel mounting type with metal end plates and insulated stationary plates as shown on Sheet No.1 (17). Its maximum capacity shall be 155 μμf (±3%), and its minimum capacity shall be 36 μμf (±3%). The radio-frequency phase difference of the solid insulating material used in the condenser shall be less than 0.5 degree; material such as porcelain, isolantite or pyrex glass will be satisfactory. The design shown locates all solid insulating material in a comparatively weak electric field.

The movable and stationary plates shall be aluminum or brass not less than 0.040 inch thick. The spacing washers shall be aluminum or brass 3/16 inch thick. The movable plates shall be keyed to the shaft which shall be of cold rolled steel and mounted in adjustable locked cone brass or bronze bearings. The bearings shall be so adjusted that the movable plates are centrally located between the stationary plates, that there is no vertical or lateral motion of the shaft, and that the shaft turns with equal friction throughout. No stops shall be used. The control for varying the settings of the frequency meter shall be geared to the movable plates through gears having a ratio of at least 8 to 1, with an adjustment provided for taking up backlash.

The shape of the movable plates of the condenser, and the ratio of maximum to minimum capacity, are such that the calibration curve when plotted between frequency and condenser setting will be approximately a straight line. If the frequency meter calibration curve is not a straight line this would indicate that the ratio of maximum to minimum capacity is not the right value. The correct ratio should be obtained by varying the minimum capacity rather than the maximum capacity. The minimum capacity may be varied by the use of an auxiliary stationary plate mounted on the stationary plate supports between the group of stationary plates and the condenser end plate so that its position with respect to the condenser end plate may be varied and locked by nuts on the stationary plate supports. The dimensions of the movable and stationary plates are given on Sheet No.3 (18) and (19).

Condenser Dial.- The nickel-plated condenser dial shall be suitably and rigidly fastened to the movable plates. The circumference of the scale shall be accurate with respect to the center of the condenser shaft and shall be accurately engraved in 110 equal divisions in such a manner that 100 divisions equal 180

degrees. Beginning with 0, every tenth division shall be numbered. The numbers shall be between the scale and the center of the dial. The lines marking every tenth division shall be approximately 3/8 inch long, those marking the fifth division between them shall be approximately 5/16 inch long, and the intermediate divisions shall be approximately 1/4 inch long. The dial shall be so marked that increasing scale reading gives decreasing condenser capacity. The dial is to be so mounted on the shaft that the long side of movable plates starts to move out from the fixed plates as the scale reading starts from zero.

The scale shall be fitted with a vernier scale of the same material as the large scale with 10 divisions on the vernier equal to 9 divisions on the large scale. The vernier divisions shall be numbered 0 on the first line and 10 on the eleventh line. The first and eleventh lines shall be slightly longer than the middle or sixth line, and the intervening lines shorter than the sixth line. The edge of the vernier shall be concave to a radius equal to that of the large scale minus 3/32 inch and shall overlap the periphery of the scale by 3/32 inch.

All divisions on both the vernier and scale shall be hair lines. The condenser scale and vernier shall be mounted below the panel and read through a dust-proof glass-covered window in the panel. The line of contact between the vernier and scale shall be at the edge of the vernier and not at the edge of the scale.

Coils.- Four inductance coils shall be furnished. The windings shall be on threaded hard rubber tubing approximately 3 3/16 inches in diameter and enclosed in a wooden box of the same material as the cabinet and provided with a suitable hard rubber terminal block and terminals. Provisions shall be made on the terminals so that the coil may be connected in the circuit in one manner only and so that the binding post thumb nuts can not be completely removed by vibration or otherwise. On each terminal block between the terminals there shall be engraved the number of the coil and its frequency range. A detailed sketch of the coils is given on Sheet No.3. The wire used in winding the coils shall be bare solid copper wire. In winding the coils the wire shall be pulled taut and the ends secured in holes in the tubing. No varnish, wax or binder of any kind shall be used on the coils. The completed coils should meet the following conditions.

Coil	Frequency Range	No. Turns	Winding Pitch	Size of Wire.
1	1390-2700	29	1/24 in.	#22 AWG
2	2450-4800	15	1/16 in.	#18 AWG
3	4400-8700	7	1/16 in.	#18 AWG
4	8100-16300	3	1/16 in.	#18 AWG

Indicating Instrument.- The device for indicating resonance shall be a Weston Model 425 radio-frequency thermogalvanometer, or equivalent, with a scale of 100 divisions and requiring not more than 115 milliamperes for full scale deflection. This instrument shall not be connected directly in the main circuit but shall be inductively coupled to it, as follows. Two two-turn coils shall be provided, of No.16 AWG bare copper wire, wound on a threaded piece of hard rubber tubing approximately 2 3/16 inches in diameter mounted below the panel. The coils shall be separated approximately 3/8 inch. One coil shall be connected in series with the frequency meter circuit, the other is connected to the thermogalvanometer terminals. The hard rubber tubing and coils are shown on Sheet No.1 (37).

Panel.- The horizontal panel on which the parts are mounted shall be sheet aluminum 1/4 inch thick and not larger than 9 1/2 inches long by 7 5/8 inches wide. A hard rubber terminal block with terminals and non-removable binding post thumb nuts shall be provided as shown on Sheet No.1 (7) and (9). A connecting link as shown on Sheet No.1 (14) shall be provided for connecting and supporting the coils. The panel is held in place in the cabinet by four 8-32 machine screws countersunk in the four corners of the panel. The four machine screws fit into four brass blocks shown on Sheet No.1 at (4), each of which is held in place by two 8-32 machine screws countersunk through the sides of the box.

Assembly.- The various parts must be securely fastened in position and shall be connected as shown in diagram on Sheet No.3. All binding nuts must be tightened and soldered in position or provided with lock washers. All connecting wires must be bare and self-supporting and of a size not less than No.10 AWG (B&S). All wire must be tinned or nickel-plated copper. No soldering flux showing acid reaction shall be used, and all excess flux must be removed. When connections are required to aluminum parts they shall be made by drilling and tapping a hole in the aluminum and inserting a tight brass screw. The connection can then be soldered to the brass insert.

Cabinet.-The frequency meter shall be completely housed in a well seasoned baywood or walnut cabinet whose outside dimensions shall not be greater than approximately 10 inches long, 8 1/8 inches wide, and 9 1/8 inches deep. The thickness of the material shall be 1/2 inch, and all joints shall preferably be dovetailed.

The cover shall be fitted with separable hinges and shall be sufficiently deep to accommodate the four coils clamped in two groups on the under side as shown on Sheet No.2. The clamps shall be lined with felt and shall hold the coils securely and also permit easy removal. Strips of felt shall be provided on the under side of cover to prevent marring the finish of the coil boxes. The top of the cabinet shall be fitted with a handle carrying the frequency meter. Two clasps shall be provided to hold cover positively shut when instrument is carried. No lock with key shall be used.

The walls and bottom of the cabinet shall be shielded with sheet copper not less than 1/32 inch thick. This shield shall be soldered at the joints to the shape of the inside of the cabinet and shall lap over the upper edges in such a way that the horizontal panel will make electrical contact with the shield on the inside of the cabinet. Any seams in the shield should be closed by soldering. The shield shall be securely fastened within the cabinet by means of a number of 3/16 inch round head brass screws.

The under side of the cabinet shall be provided with four rubber shock absorbers.

Finish.- All the exposed metal parts shall be heavily nickel-plated, bright finish, except the panel and the thermogalvanometer which are to be finished in black. The cabinet and coil boxes shall be stained somewhat darker than the natural color of the wood used and given at least two coats of a satisfactory rubbing varnish.

Marking.- A frequency meter made in accordance with these specifications may have engraved in a suitable space, "Frequency Meter, 1500 to 15000 kilocycles, Bureau of Standards Type K," followed by the name of the maker.

Drawings.- Nos.978A, B and C, giving general horizontal view of panel, elevation, condenser plates, inside of cover and details, may be obtained by anyone actually requiring them for construction of this instrument, upon application addressed to Bureau of Standards, Washington, D.C.

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